
Space Weather Technical Forecast

Issued on Saturday, 22 April 2023 at 13:03 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Strong geomagnetic storm/G3 from CME Likely early on Day 3 (Monday 24 April). Slight chance of M-class flares (R1-R2; Minor-Moderate radio blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity rose to Moderate in the UTC day of Friday 21 April, with a late M1.7 flare observed at 21/1812UTC on a mostly smooth declining X-ray flux trend as recorded at GOES16. A few C-class flares followed thereafter. The peak flare in the period emanated from a large centre-disc flare and filament eruption combination, with one end of this filament formerly anchored in the vicinity of AR3283 - an otherwise unassuming Bxo/Beta. An associated Type IV radio signature was observed at 21/1759UTC, and a small EUV wave was seen centred on AR3283.

The filament in question formed part of a longer feature that spanned near 20 degrees solar longitude, and although much of this was significantly disturbed, the eastern portion at least appears to have remained in place on the Sun. The resulting Coronal Mass Ejection (CME) was clearly visible in many wavelengths in subsequent satellite imagery, eventually manifesting on coronagraphs later in the UTC evening as an apparently twin-lobed shock forming an 'infinity'-shaped symbol centred just west of centre-disc. The bulk of ejecta was apparently directed south and west of the Sun-Earth line, with the CME occulting the southwestern solar horizon corona in AIA304 between 1815 and 1830UTC.

The above region was one of six regions on the current solar disc, All of the regions were generally stable with little overall change noted, including the largest - AR3282 in the northwestern quadrant. This showed a degree of fading of some of its intermediate spots, while its leading large penumbral spot became more symmetric with time. This finished the 24 hours as an Fho/Beta. Other events in coronagraph imagery included a high latitude northwest-directed narrow CME, and a western limb event, however neither is expected to affect Earth. Discussion around a 'ghost' CME from a coronal hole realignment prior to this reporting period is now in all likelihood rendered less impactful following the recent eruption of the 21/1812UTC centre-disc filament.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by ACE at L1, was at mostly slow-ambient levels with an enhancement to slightly elevated and was also characterised by minor SSBCs. The solar wind density was at near to mostly below average levels. The IMF was stable at or below 7nT over the 24 hours, while the north-south component ranged between +6/-7nT, being mainly anti-aligned. The phi angle was negative (towards the Sun) for much of the period following a more variable regime to start the period. The net effect of the above solar wind measures was Quiet to Unsettled, with a provisional peak Kp of '3o' in the 15-18, 18-21, and 21-24UTC periods, likely the result of the SSBCs.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, was at Background levels, until around midnight UTC when an increase in activity was noted but levels remained below minor storm (S1). High energy electron flux

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(greater than 2MeV) as measured at GOES16 was at Normal Background levels. The associated 24-hour electron fluence was well below the Active threshold on a steady trend, with 1.43e6 integrated pfu observed at 22/0001UTC.

Four-Day Space Weather Forecast Summary

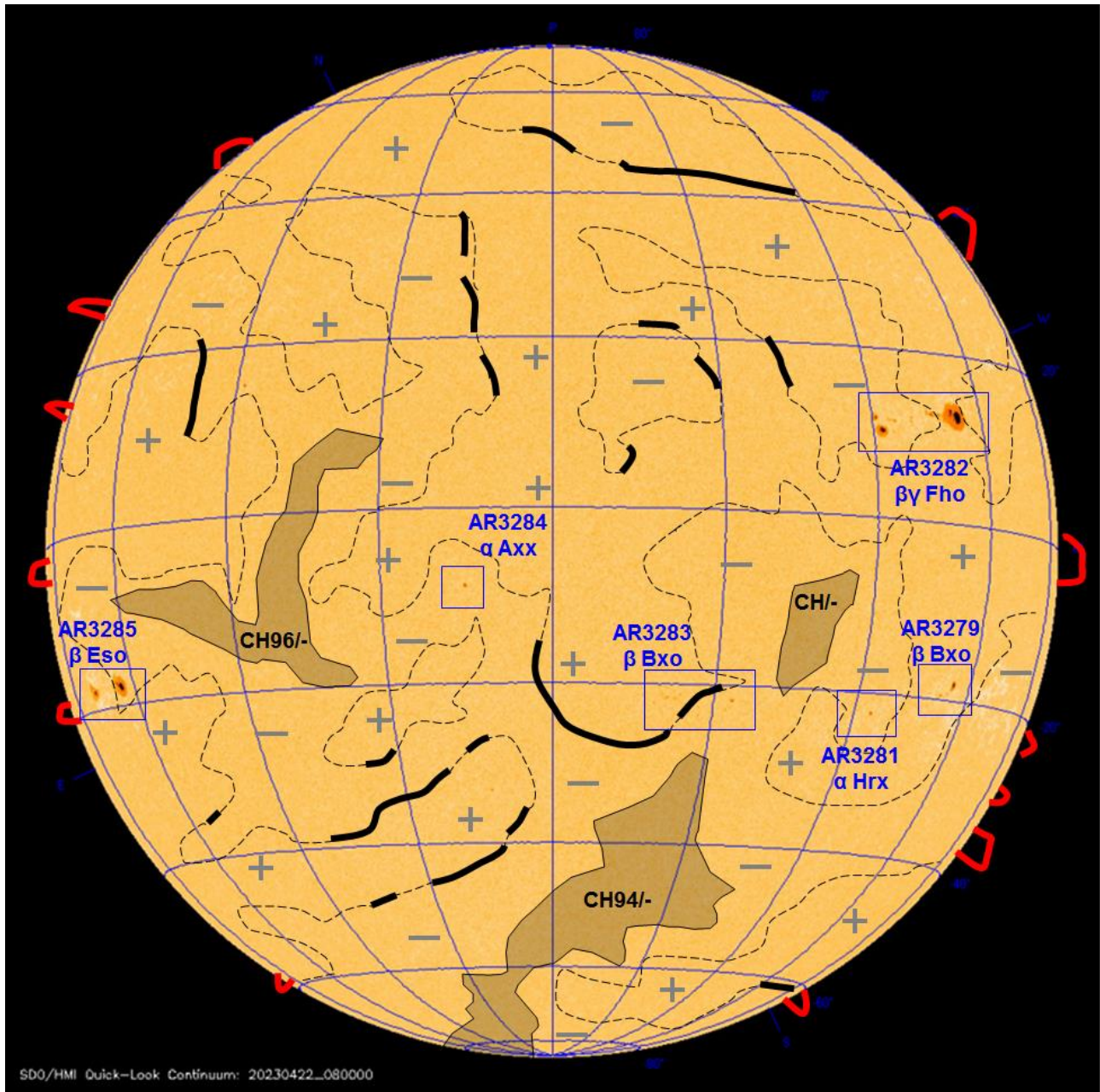
Solar Activity: Solar activity carries a Slight Chance of isolated Moderate activity, mainly due to AR3282 but perhaps also from the new region rotating onto the southeast limb, otherwise activity is most likely to remain Low.

Solar Wind / Geomagnetic Activity: The large full-halo CME from the 21/1812UTC M1.7 flare and filament is due to arrive in the early hours of the UTC day of Monday 24 April (Day 3). Earth is otherwise in a slightly elevated solar winds regime at present. There is a chance of either CH94 or CH95 (both negative) affecting Earth in the next 36 hours, with solar winds perhaps reaching elevated for a short spell (450-550km/s), although this aspect carries low confidence, and a slower regime could equally persist throughout.

A Strong Geomagnetic Storm/G3 is considered Likely on Monday 24 April from the 21/1812UTC flare and filament. A Minor to Moderate geomagnetic storm (G1/G2) is Expected, and there is some bleeding of these probabilities into neighbouring UTC days.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is most likely to persist at Background levels, although there is a slight chance of S1 or greater, mainly due to AR3282. High energy (greater than 2MeV) electron flux is currently at Normal Background levels, with little change expected, although a slight increase is possible later in the period in response to HSS effects. The associated 24-hour integrated fluence is expected to remain below the Active threshold (1e8 integrated pfu), but with an increasing trend later in the period.

Figure 1. Solar Analysis Valid 0800UTC, 22 April 2023.



Key: Filament —, Prominence —, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

The dominant feature of the four-day forecast is the M1.7 21/1812UTC CME from centre-disc. Available imagery for the event is very good, although the very narrow angular difference between STEREO A and Lasco perspectives obviously introduces error bars into the measurement, as does the fact that the CME ejecta itself is rather complex, with numerous lobes of the shock apparently interacting - especially to the northwest of the Sun-Earth line. The main ejecta from this event has been assumed to be that seen heading narrowly southwest, with the CME's angular width therefore significantly impinging on the Sun-Earth line. Earth is currently with a slightly elevated solar wind regime. CH94 or CH95 (both negative) may become geoeffective into Day 2 (23 April) however this is not supported by MOSWOC Enlil, which favours a continuation of ambient conditions. CH94 is a high latitude feature and may pass below Earth, with this feature also smaller and presumably slower than on the previous rotation. CH95 is more centrally located, but had been obscured by sunspot flux to the south and east of it rendering it invisible for a time, however the M1.7 flare and filament eruption has 'reopened' this feature. Evidence from late last working week of CH95's stature at that time suggests solar wind speeds may reach elevated levels (450-550km/s).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	1	30	80	30
Strong	G3	No	1	20	50	10
Severe	G4	No	1	1	10	1
Extreme	G5	No	1	1	1	1

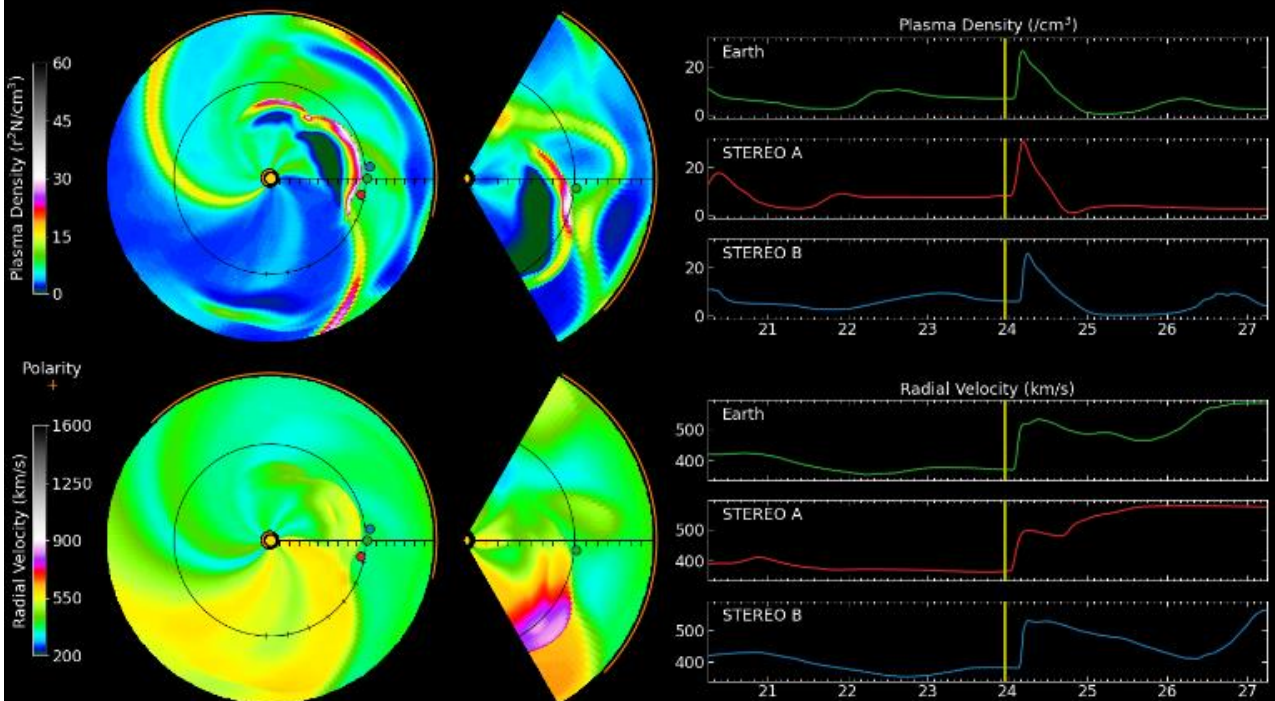
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
21/2121	Full Halo	Flare/Filament eruption	Centre-West	1081 km/s	24/0200UTC	Strong Geomagnetic Storm (G3) Likely

Figure 2: Met Office ENLIL model output along with Ensemble showing forecast arrival time of the CME this coming guidance period.



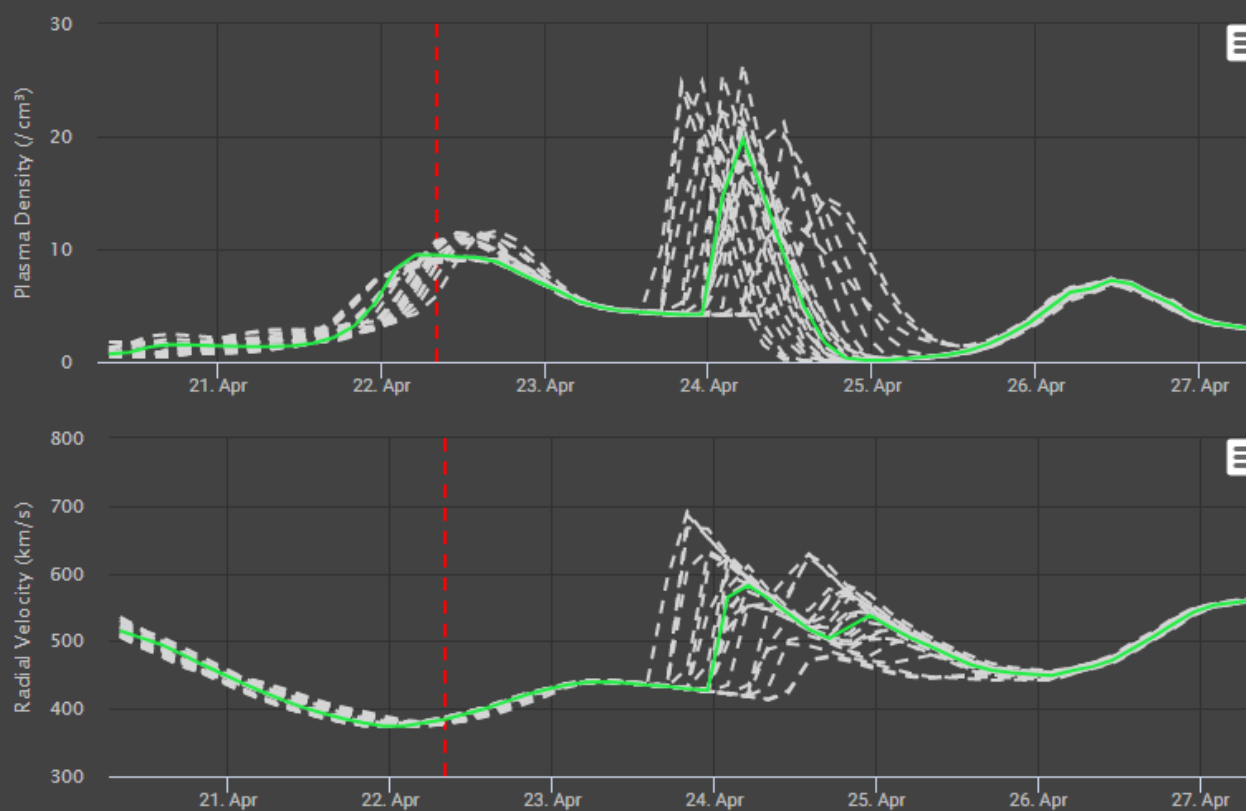
2023-04-23 23:00:00



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Enlil v2.7 | WSA v4.5 | Model Run: 2023-04-22T06Z

2023-04-22 08:00



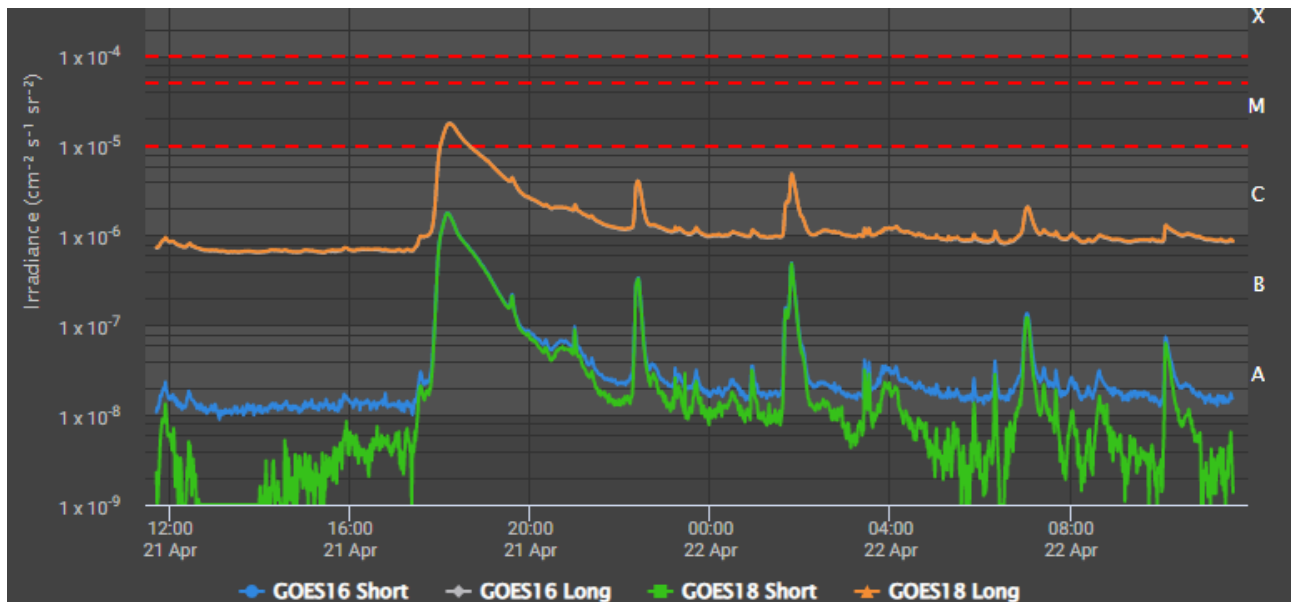


Radio Blackouts - X-Ray Flares:

There are six sunspot regions on the visible disc, with the largest and nominally most threatening AR3282 upstaged by the apparently unassuming AR3283 near centre-disc. This particular region appears as a simple Bxo/Beta upon delivering an M1.7 flare at 21/1812UTC, perhaps driven by sub-'surface' structures or more likely due to its close proximity to being perhaps triggered by the large filament eruption to its east. Activity from this spot group may prove to be an exception, with the X-ray trace at GOES16 otherwise quiet and declining, and with all numbered front-sided groups stable, including the largest. At present there is no strong evidence for large eastern solar horizon arrivals, so the Chance of M-class flares is proposed at 20-30% throughout the coming four-day guidance period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	20	20	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: X-ray flux plot at GEO showing recent flares with M1.7 flare observed on 21 April.





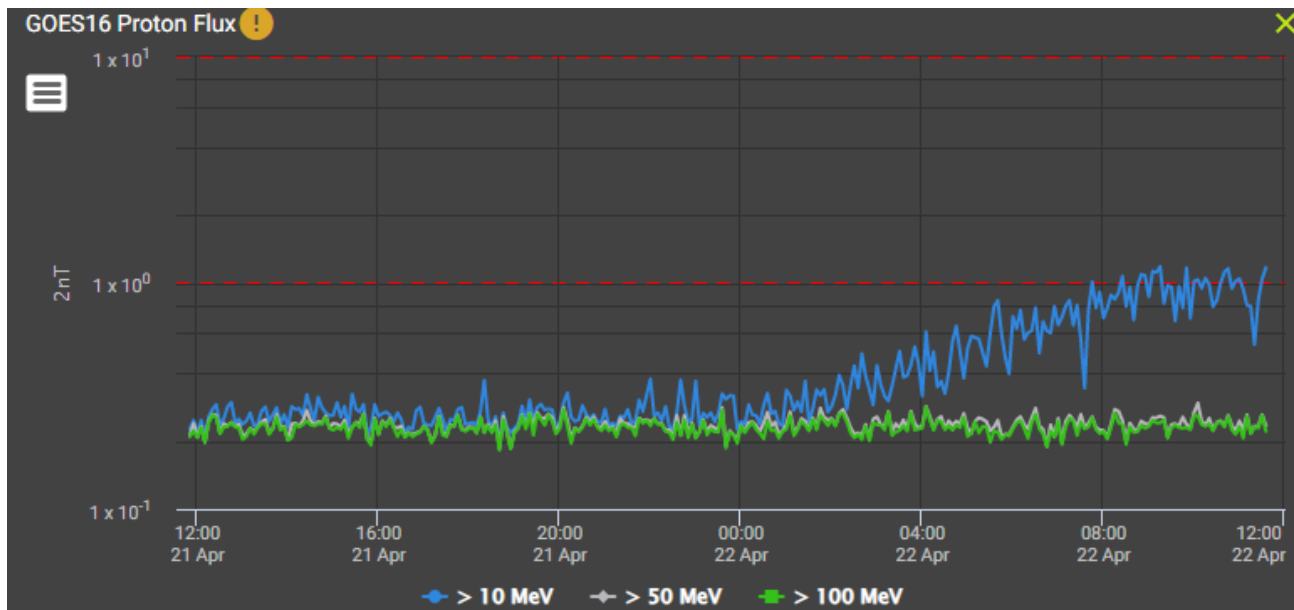
Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES16, is currently at Background levels, with a minor response noted in the proton spectrum at GOES16 after the M1.7 flare from near AR3283. This is reflected by a slight response recorded in lower energies at ACE EPAM LEMS, although there may be other reasons for this (noise or perhaps even the 15 April CME). There is a daily Slight Chance (10%) of reaching S1 or greater, especially should any larger flares occur, with this still thought most likely from AR3282, positioned in a more favourable position, in the northwest quadrant.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	10	10	5	5
Very Active	$\geq \text{S3}$ *	No	1	1	1	1

* $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

Figure 4: Proton flux plot at GEO showing increase in activity following M-class flare on 21 April.



High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy (greater than 2MeV) electron flux is currently at Normal Background levels. The most likely drivers of any change to this state of affairs are the twin negative coronal holes CH94/- and CH95/-, however MOSWOC Enlil does not currently support either becoming geoeffective. Should persistence methods prove accurate, a 450-550km/s fast wind may occur, however even this would likely be marginal for electron flux to breach the diurnal High threshold. The chances of 24-hour integrated electron fluence breaching Active are considered Slight in the period, probably reaching a new equilibrium into the new UTC working week, with the caveat that the driving coronal hole fast winds and possibly interrupting CME(s) carry a lowering of confidence.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	10	10
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 5: High energy electron flux at GEO and Met Office REFM output over past three days.

